
Summary of Vulnerabilities

During the field verification effort, the Chemical Safety Vulnerability Review identified 35 facility- and site-specific vulnerabilities. Although these vulnerabilities are indicative of serious chemical safety issues, none represents imminent danger to the public, to worker health and safety, or to the environment. These facility- and site-specific vulnerabilities were grouped into the eight generic vulnerabilities with broad application to the DOE complex that are described in this chapter. The review did not include a comprehensive survey of chemical safety at all DOE facilities that use or contain hazardous chemicals. Nonetheless, it is the Working Group's judgment that these generic vulnerabilities are representative of vulnerabilities at other sites across the DOE complex. Specifically, the circumstances or conditions that gave rise to the generic vulnerabilities exist elsewhere; the types and quantities of chemicals used at other sites are comparable; the processes or operations performed are common to multiple sites; or the management practices used by other sites for chemical safety are comparable. The actual applicability of these generic vulnerabilities to specific sites or facilities not reviewed by the Working Group cannot be determined without further evaluation. This review should be used as a guide or "roadmap" for managers in the identification, prevention, and mitigation of vulnerabilities at those sites and facilities.

In the discussions that follow, the overall nature of each vulnerability has been characterized and is illustrated by specific examples of that vulnerability excerpted from field verification reports. (See Appendixes D through L.)

Characterization of Chemicals

Chemical inventories at many DOE facilities have not been adequately characterized.

Description of Vulnerability. Chemical inventories at many DOE facilities have not been adequately characterized to determine the types or quantities of hazardous substances they contain. This situation increases the likelihood that workers will be exposed to hazards that are not adequately recognized or mitigated. Specifically, the presence of poorly characterized hazardous materials increases the risk of worker injuries or environmental releases during routine work activities, when D&D operations are conducted in facilities containing uncharacterized hazardous residues, and in the event of emergencies involving uncharacterized materials.

Efforts to characterize hazardous materials, particularly abandoned chemicals and chemical residues, are in the early stages of development at a few DOE sites. These activities are a result of

individual site initiatives rather than a comprehensive Department-wide program for the characterization of hazardous materials. In fact, neither DOE Headquarters nor DOE line organizations have developed and implemented consistent requirements for the characterization of hazardous substances. As the examples below illustrate, consistent hazardous material characterization requirements generally do not exist, despite significant quantities of uncharacterized chemical residues in DOE facilities. These observations indicate that DOE and contractor organizations must increase their efforts to prevent and mitigate the potential risks associated with uncharacterized chemicals.

Examples. Hazardous chemicals and wastes have been produced over several decades of operations at several DOE sites. At **Los Alamos**, efforts are being made to characterize such materials for eventual disposal, but the field verification team found chemicals in the form of uncharacterized gases stored in cylinders at Area L in Technical Area (TA)-54. (See Vulnerability CSVr-LANL-CH-01 in Appendix K.) Many of the cylinders are old and corroded, and the chemicals they contain include flammables (e. g., propylene, isobutane, hydrogen, and methane), corrosive gases (e.g., hydrogen fluoride, hydrogen chloride, nitric oxide, and sulfur dioxide), and toxic gases (e.g., arsine, phosgene, cyanogen, and phosphine). (See Chemical Storage Practices, p. 32.) Similarly, the field verification team at Los Alamos observed 30 drums of uncharacterized waste at Area L. These drums contain chemical wastes in a variety of hazard classes including acids, oxidizers,



Cylinders of uncharacterized gases are stored in Area L at Los Alamos.



Drums of uncharacterized chemical waste are also stored in Area L at Los Alamos.



flammables, and caustics. In TA-3, Building 154, the team observed four tanks containing about 3,100 gallons of uncharacterized chemical wastes. Personnel assigned to the Chemistry and Metallurgy Research Facility indicated that this waste has been housed in their facility for at least 18 months without being characterized. An abandoned physical chemistry laboratory in the same Los Alamos facility has held four drums of uncharacterized hazardous chemical wastes for about 2 years.

Hazardous chemical wastes in the **Oak Ridge National/ Laboratory** Contractor Landfill (Area 7658) are only partially characterized, and their hazard potential to the public has not been established with any degree of certainty. (See Vulnerability CSV-OR-ORR-01 in Appendix E.) This area is no longer protected behind security fences and, thus, is increasingly accessible to the public.



Chemical residues that have not been properly characterized are known to exist in a variety of locations. For example, the piping and drains of Building 881 at **Rocky Flats** contain chemical residues that are only partially characterized. (See Vulnerability CSV-RFP-000-01 in Appendix I.) These residues represent potential hazards to workers during future D&D operations. Several large tanks stored in Room 4101 of Building 374 at Rocky Flats are believed to contain dilute acid solutions, although the contents are labeled as concentrated acid. This situation has not been fully documented.

At Oak Ridge, uncharacterized hazardous material residues have been left in the process equipment and piping of several surplus and inactive facilities. (See Vulnerability CSV-OR-ORR-01 in Appendix E.) In the 9201-4 Production Building at the Y-12 **Plant**, these residues are the result of operations involving polychlorinated biphenyl oils, mercury, lithium chloride, lithium hydroxide, lithium carbonate, and sodium hydroxide. In addition to unknown hazardous materials, residues of uncharacterized acids, bases, and carcinogens exist in Building 3047 at Oak **Ridge National Laboratory**. The sump for the shielded-cell facility in Building 3047 is known to contain a radioactive chemical residue. (See Vulnerability CSV-OR-ORR-03 in Appendix E.) The manner in which this material reached the sump is unknown, but it may have been transferred through a ventilation duct or via a leaking pipe. No device is in place to sample or flush the sump basin; thus, its precise contents are unknown. Chemical processing is no longer conducted in the shielded cells of Building 3047; however, past work in these cells involved acids, bases, solvents, and other materials that may still be in the sump. The chemical hazards associated with this uncharacterized residue have not been determined.



Uncharacterized solid residues were found at the base of an abandoned powerhouse smokestack at Savannah River.

At **Savannah River**, uncharacterized solid residues had seeped from beneath the cleanout door and were found at the base of the smokestack at the abandoned 184-P Power House. (See Vulnerability CSV-SRS-000-02 in Appendix F.) Chemical residues at the 412-D Heavy Water Extraction Facility may have contributed to a November 11, 1993, incident involving the apparent inhalation of noxious gases by an employee after a co-worker used a torch to

cut a pipe containing the residues. Another uncharacterized residue found in the Heavy Water Extraction Facility was described as an oily substance with a pH of about 3.3. At the time of the field verification visit, a sample of the residue had been submitted for analysis, but despite ongoing D&D operations, a full characterization had not been pursued vigorously.

Unanalyzed Hazards

Description of Vulnerability. During the course of this review, unidentified and unanalyzed hazards associated with the use or handling of chemicals were observed at numerous DOE sites and facilities. The review further determined that many DOE sites and facilities do not have adequate management systems to analyze processes and equipment for chemical hazards or to prepare and issue formal “hazards analyses.” The purpose of a hazards analysis

is to identify and document operational hazards and to determine appropriate means for minimizing or mitigating the potential consequences of such hazards to workers, the public, and the environment.

Formal chemical hazards analyses have never been conducted for many nonnuclear facilities.

Safety-related documentation at sites

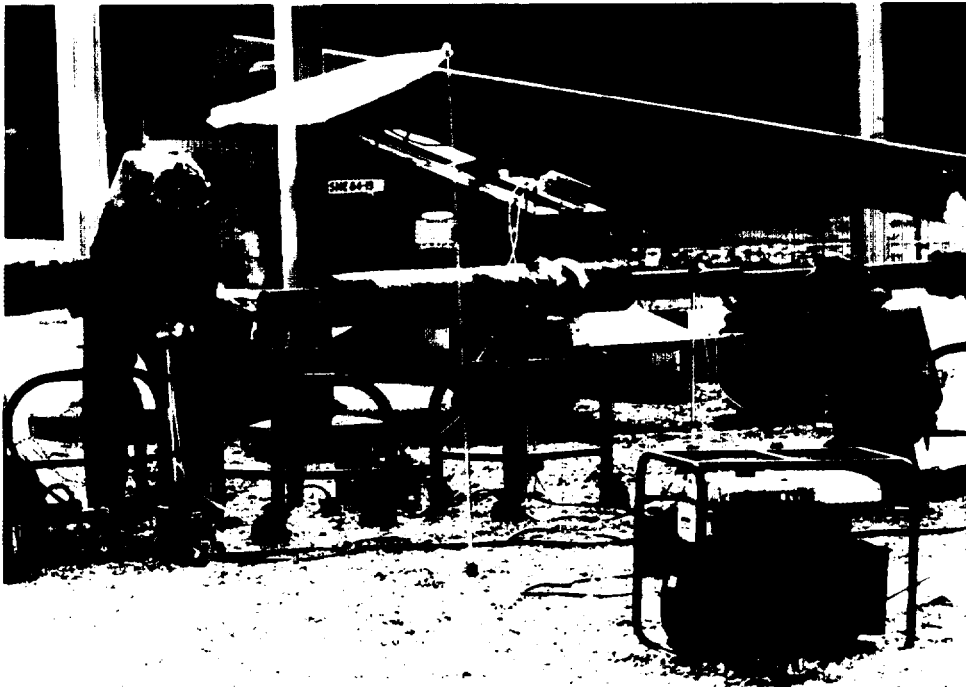
throughout the DOE complex is often out-of-date and incomplete; moreover, formal chemical hazards analyses have never been conducted for many nonnuclear facilities, despite the requirement to do so by DOE 5481.1 B, “Safety Analysis and Review System: dated September 23, 1986.

The examples provided in this subsection confirm that unanalyzed chemical hazards are common throughout the Department. DOE Headquarters is responsible for requiring and enforcing the implementation of an effective hazards analysis system at all DOE sites; however, the responsibility for analyzing chemical hazards for individual activities or facilities rests with site management. (See Emphasis on, Commitment to, and Implementation of Chemical Safety Programs, p. 46.) Because operations at all sites involve the use of hazardous chemicals, local DOE and contractor organizations must assess the quality of their hazards analysis systems, determine the status of the hazards analyses for ongoing chemical activities, and correct the deficiencies identified. These measures are required to ensure that operating and maintenance personnel are aware of all chemical hazards and are prepared to address them safely and effectively.

Examples. The dangers posed by unanalyzed hazards are exemplified by the incident involving a **Savannah River** worker who apparently inhaled noxious gas after a pipe containing chemical residues had been cut with a torch. (See Characterization of Chemicals, p. 19.) This task had not been formally analyzed for potential hazards related to a noxious gas release or for the effects of heating residues with a torch. After the incident, a Type B accident investigation was conducted, and the site introduced improvements in the process based on a hazards analysis completed before work resumed. Another operation at Savannah River that was performed without benefit of a hazards analysis involved the removal of carpet from specified areas in Buildings 773-A and 735-A. Tile containing asbestos was found underneath the carpet, seriously complicating efforts to complete the task and requiring significantly more resources than had been anticipated or provided.



A pipe containing chemical residues, similar to the condition pictured here, was apparently the source of noxious gases released during cutting operations.



As part of a Type B investigation into a worker's apparent inhalation of noxious gases, sampling was performed to identify the extent of the potential hazards involved.

D&D operations have the potential to be significantly more hazardous because their technologies and requirements are unknown or unfamiliar to many workers.

work and the Department's general lack of experience in this area. The incident involving the possible exposure of the worker at Savannah River exemplifies the importance of recognizing potential hazards related to D&D activities—hazards that may be even less apparent than those related to routine operations.

D&D operations have the potential to be significantly more hazardous because their technologies and requirements are unknown or unfamiliar to many workers.

At *Hanford*, approved work plans for job hazards analyses at the Chemical Engineering Laboratory do not always receive indepth review by industrial hygiene and/or industrial safety personnel. (See Vulnerability CSV-RL-HAN-02 in Appendix G.) In many cases, approvals are granted perfunctorily without conducting thorough analyses of the proposed work. A near-miss event still under investigation occurred at Hanford on April 20, 1994. Relying on information provided by a subcontractor, maintenance personnel were in the process of removing a blank in a low-pressure steamline without ensuring that the required double-valve isolation was in place upstream. The work began without management approval, which would not have occurred had a formal hazards analysis been prepared, reviewed, and approved. Although this near miss is not typical of chemical safety incidents, it illustrates the danger that can be caused by insufficient analysis of hazards for special operations. It also illustrates that job hazards analyses at Hanford are not always reviewed thoroughly or rigorously by management. These factors can contribute to an increased potential for personnel exposure to chemicals, as well as to other hazards in the workplace.

Weaknesses were also observed in programs for identifying, characterizing, and mitigating chemical hazards at **Sandia**. (See Vulnerability CSV-SNUNM-MO-02 in Appendix L.) For example, a project to install an acetone distillation apparatus in Building 878 received only limited input from industrial hygiene specialists. Acetone is a volatile, highly flammable liquid. The ventilation flow rate was designed to preclude generation of an explosive atmosphere, but no formal hazards analysis was performed; hence, there was no documentation that this flow rate was sufficient to protect workers. The facility design complied with code requirements and included venting panels to relieve pressure from an explosion involving up to 120 gallons of acetone. A fire safety engineer supporting the project determined that the Uniform Building Code required backup power for the ventilation system serving the distillation apparatus. This determination was based on the

specialist's opinion that the system was not closed. When backup power was found to be unavailable, the facility design was modified accordingly, based on a second opinion from another fire protection engineer that the system was closed. A mechanism has not been established at Sandia to document or resolve such dissenting opinions, and an accident analysis covering loss of power has not been performed. At the time of the field verification visit, the distillation apparatus installation had not been turned over to the operating group. If a problem does arise, no formal mechanism will be in place to advise the operating group or DOE about these contradictory opinions concerning the system's compliance status with established codes.

At Sandia, a hazards analysis for chemical operations is provided by the responsible line organization, approved by line management, and reviewed by the appropriate ES&H coordinator. Unfortunately, hazards analyses are not prepared in accordance with clear and formal guidance, and Sandia employees responsible for performing and recording these analyses are not provided adequate training. As a result, there is no assurance that all hazards have been addressed; that potential synergistic effects have been evaluated; or that workers, the public, and the environment will be adequately protected.

At Lawrence *Livermore*, a wide variety of hazardous chemicals is used for experimental research, development, and testing. Yet, safety analysis documents for laboratory facilities (e.g., the B-222-229 Complex, B-235, the B-825-827 Complex, and Area 300) do not contain accident scenarios (including potential effects on workers and the public) or evaluation of safety systems that would prevent or mitigate those scenarios. (See Vulnerability CSV-LLNL-MO-01 in Appendix D.) Hazardous chemicals used in these facilities include beryllium hydride (toxic and a suspected carcinogen), lithium hydride, lithium beryllium hydride, heavy metal (uranium and thorium) compounds, flammable solvents, cryogenics (liquid nitrogen and liquid argon), and explosives. Overall, weaknesses observed in the hazards analysis program as it affects chemical safety at Lawrence Livermore included lack of explicit definition for conditions under which project work plans are required to address new or modified operations or equipment, inadequate implementation of guidelines for submitting project work plans, and the absence of accident analyses.

An effective emergency management program requires that chemical hazards be assessed to enable informed judgments about the resources needed to respond to emergencies and to provide

adequate protective measures. Some sites, including **Brookhaven** and **Idaho National Engineering Laboratory**, have not completed hazards assessments of chemical activities to support emergency management. (See Vulnerability CSVN-BNL-000-02 in Appendix J and Vulnerability CSVN-INEL-EMP-01 in Appendix H.) Previous reviews by the Chicago Operations Office at Brookhaven identified the need for hazard assessments to determine the extent and scope of emergency planning and preparedness activities required for managing events involving chemicals. At Idaho National Engineering Laboratory, a hazards assessment to determine emergency action levels had not been completed as of the time of the field verification visit, although one had been initiated. (Emergency action levels are specific indicators used to determine occurrence reporting categories and emergency classes for serious incidents, as well as to make determinations about the resources needed for emergency response or for appropriate protective measures.)

Commendable Practices. The field verification team observed several commendable practices that partially address problems related to unanalyzed hazards at DOE sites. **Brookhaven National Laboratory** uses a graded approach, based on the level of hazard, to review facilities and operations (i.e., operations with increasing hazard levels receive correspondingly more rigorous health and safety review and independent laboratory process review). At **Oak Ridge**, Martin Marietta Energy Systems uses both corporate-wide and site-specific procedures to ensure that all stages of the life cycle of an operation are treated with an appropriate degree of rigor. A substantial effort has been made to apply this philosophy to processes used for evaluating and reducing hazards. At the **Idaho National Engineering Laboratory**, Westinghouse Idaho Nuclear Company is developing a nomograph to determine evacuation distance requirements for chemical incidents.

Past Chemical Spills

Disturbing the soil at spill sites can expose workers to hazardous chemicals and cause environmental releases.

Description of Vulnerability. During their operational lifetime, most DOE sites have experienced chemical spills and other releases that have contaminated the soil. Such spills are believed to have been common in the past and are of concern for virtually all DOE sites. In most cases, the resulting chemical contamination has been allowed to remain in the soil, based on the assumption that it did not constitute a hazard as long as the soil remained undisturbed. Given the Department's increased emphasis on site remediation and D&D, the impact of these old spills on current operations needs to be

reexamined. Remediation and D&D operations, including those related to environmental restoration, often require excavation or other construction-related activities. Inadvertent disturbance of the soil at spill sites has the potential to expose workers to hazardous chemicals and to cause further environmental releases.

The examples provided here illustrate the magnitude of problems associated with past chemical spills. These examples also describe programs that are in place at most sites to define the scope of and mitigating actions for this vulnerability. However, continuing efforts by local DOE and contractor organizations are required to identify the location and extent of unknown or uncharacterized spills and to prevent or minimize worker exposures and environmental releases.

Examples. Four hundred spills, leaks, and discharges of hazardous chemicals have been identified at the **Idaho National Engineering Laboratory, 83** of which occurred at the Idaho Chemical Processing Plant. (See Vulnerability CSV-INEEL-CH-01 in Appendix H.) Some of these spills to the soil originated from process lines and bulk storage areas. Intentional discharges of hazardous materials have



Numerous spills, leaks, and discharges of hazardous chemicals are known to have occurred at the Idaho Chemical Processing Plant.



also occurred. Known locations for such discharges at the Idaho National Engineering Laboratory have been at least partially characterized and, in some cases, remediated. In addition, administrative controls have been put in place to restrict access to those areas known to be contaminated. In the absence of reliable records for the early history of the Idaho National Engineering Laboratory, it seems likely that other spill and discharge sites will be identified that could pose threats to worker health and safety.

Several leaks and spills involving nitric acid, sulfuric acid, hydrofluoric acid, and aluminum nitrate occurred between 1950 and 1980 in the bulk chemical storage area adjacent to Building CPP-621 at the Idaho Chemical Processing Plant. The details of these leaks are not well documented. "French drains" were originally used to dispose of acid leaks and spills. Other discharges have occurred in the earthen pipe trench leading from the storage area to the chemical processing building. (A plastic liner was recently installed in this trench.) At the waste tank farm for the processing plant, two known instances of high-level liquid waste (containing hazardous chemicals as well as radionuclides) leaking to the soil have been documented. At least one leak at the tank farm is known to involve cooling water that contained potassium bichromate. Pipes used in the transfer of wastes to the tank farm have also leaked. In Building CPP-601, condensate leaked from the vent tunnel when a pipe corroded. Examination of sections of lines removed from Building CPP-601 showed no evidence of additional leaks; however, the lines could not be examined in their entirety. Thus, the possibility of other undetected leaks of hazardous materials cannot be disregarded. These leaks, spills, and discharges create the potential for worker exposure to chemical hazards during environmental restoration, construction, D&D, and other activities that disturb the soil.

At Oak Ridge, hazardous materials have escaped and contaminated the soil around and beneath the 9201-4 Production Building at the Y-12 Plant. (See Vulnerability CSV-OR-ORR-01 in Appendix E.) Contamination of the building from chemical leaks involving mercury, lithium chloride, sodium hydroxide, and lithium carbonate has been confirmed; subsurface contamination is assumed to have occurred as a result of seepage from sumps, floor cracks, and joints. Exposure of workers and the public to hazardous chemicals is possible whenever the soil is disturbed. Planning to control and mitigate such exposures has already begun.

At **Sandia**, waste management personnel are examining 200 known or potential release sites in an attempt to determine the extent of hazardous materials released to the soil. (See Section 2.1 of Appendix L.) Some leaks or spills involving process equipment and bulk chemical storage areas are known to have occurred. Others are the result of the dispersion of hazardous material during unconfined tests. In the past, liquid wastes were intentionally discharged via French drains, which in turn could have discharged hazardous materials to the soil. At Sandia, the potential consequences of old chemical spills have been mitigated through the preparation and implementation of procedures to control activities in proximity to unearthed waste sites, thereby protecting workers engaged in such activities from exposure to hazardous chemicals.

Planning for the Disposition of Chemicals

Description of Vulnerability. Lack of planning for reducing the quantities of hazardous and specialty chemicals increases DOE's overall vulnerability to chemical releases and exposures affecting workers, the public, and the environment. DOE has significant quantities of chemicals that are no longer required to support ongoing activities. Without an identified need for their use, such materials should be removed to minimize the potential for unnecessary worker exposures and environmental releases.

Large numbers of hazardous substances are located at many DOE sites in amounts ranging from industrial quantities of process chemicals to small laboratory quantities of a wide range of hazardous or specialty chemicals. At most sites, there is little incentive to reduce the inventory of chemicals no longer being used. As a result, chemicals

Most DOE sites have little incentive to reduce the inventory of excess hazardous chemicals.



are being held without justification or hoarded because they “might be needed later.” Chemicals held without any continuing need may be viewed as waste by regulatory agencies and could be subject to RCRA requirements. Moreover, some chemical wastes generated during past operations continue to be held because plans or technologies for their ultimate treatment or disposal have not been developed. In some cases, disposition has been delayed as a result of regulatory constraints.

As the examples in this subsection indicate, only limited progress is being made in planning for the disposition and removal of hazardous chemicals from DOE sites. Although such planning for chemical wastes is generally receiving increased attention, the same is not true for hazardous chemicals. Managers of local DOE and contractor organizations have not given sufficient priority to this aspect of planning. As a result, large quantities of chemicals are being retained at many sites, increasing the Department’s vulnerability to chemical releases and exposures.

Examples. Because of the nation’s changing defense requirements, large quantities of many unique chemicals are being held at Oak Ridge without a definitive, long-term strategy for their disposition. (See Vulnerability CSV-OR-ORR-05 in Appendix E.) An estimated 50,000 tons of uranium hexafluoride are stored over several acres at the K-25 Site. This material is being stored without engineered controls that would minimize the potential for environmental releases, even though many containers show evidence of excessive corrosion. Industrial quantities of lithium compounds have been stored for decades without plans for their disposition. (The exact amount

of these materials is restricted information.) These materials are currently stored in the K-25 Process Building in vaults that were not intended for hazardous chemical storage and under less than ideal conditions. Over 50,000 pounds of mercury have been recovered from Building 9201-4 at the Y-12 Plant and are stored in flasks (76 pounds of mercury per flask). An estimated 50,000–1 00,000 pounds of mercury remain in the pipes and tanks of the building and are currently being recovered. In addition, over 43,000 pounds of beryllium and its compounds are known to exist in Building 9201-5.

At **Hanford**, about 3,000 gallons of nitric acid and 8,000 gallons of aluminum nitrate solution are being stored in 40-year-old tanks at the Plutonium Finishing Plant, with no final plans for disposition. (See Vulnerability CSV-RL-HAN-01 in Appendix G.) About 21,000 gallons of tributyl phosphate, slightly contaminated with radioactivity, are being held at the PUREX Plant. Plans to ship this material from Hanford to the Idaho National Engineering Laboratory for treatment have been impeded because regulatory differences between Washington and Idaho prevent its transport across State lines. Although other options are being assessed, the tributyl phosphate will probably be stored for several years before plans for treatment and disposal are finalized. Forty-eight 55-gallon drums of carbon tetrachloride, a suspected human carcinogen, are being stored outside the Plutonium Finishing Plant under a tent. Although inspection of the drums is difficult, several have already shown evidence of leaks. Preparations are being made to sell the material to a vendor, but this solution may not be implemented because carbon tetrachloride could be used as a solvent in cleanup operations under an option being considered in the Environmental Impact Statement for the facility.

At the **Idaho National Engineering Laboratory**, hazardous chemicals and wastes have been stored for extended periods of time without provisions for their final disposition. (See Vulnerability CSV-INEL-CH-02 in Appendix H.) About 10,000 gallons of water used for cooling high-level radioactive waste tanks containing an estimated 500 parts per million of bichromate are being stored without secondary containment at the Idaho Chemical Processing Plant tank farm. Currently, the only plan for this material is to leave it in place until the tank farm is retired in 10–20 years, which only postpones disposition. About 1,000 gallons of hexone solvent extractant contaminated with fission products are being held in cell tankage in Building CPP-601 at the Idaho Chemical Processing Plant. Only tentative plans have been developed to transport this material to a licensed commercial incinerator for disposal. A bunker

at the Army Reentry Vehicle Facility Site at the Idaho National Engineering Laboratory holds four containers of sodium-potassium mixed waste. The containers have been stored in this location since 1974 and were last inspected in 1979. During that last inspection,

two containers showed signs of external corrosion. Representatives from the DOE Chicago and Idaho Operations Offices recently met with personnel from the Idaho Department of Environmental Quality to address treatment of this long-ignored waste.

Examples of inadequate planning for the removal and disposition of wastes generated within DOE facilities were found at **Los Alamos**. (See Vulnerability CSVN-LANL-CH-01 in Appendix K.) In TA-3, Building 154, about 3,100 gallons of waste from the hot cells located in Wing 9 of the Chemistry and Metallurgy Research Facility have been held in four tanks for about 18 months without being adequately characterized. This waste was generated in hot cells where a variety of radionuclides and chemicals was handled; how-

ever, because the material has not been characterized, the exact composition of the waste is unknown. The field verification team also observed four drums of uncharacterized hazardous chemical waste in an abandoned physical chemistry laboratory at the Chemistry and Metallurgy Research Facility. Here, too, there was little indication that specific plans had been developed to dispose of these wastes. Uncharacterized waste is a source of hazards for workers. Components of such waste can readily degrade or react with other materials to generate more serious hazards through corrosion of containers or through formation of explosive or noxious gases that provide a mechanism for their release.



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Commendable Practices. The field verification team observed commendable practices related to the disposition of chemicals at two sites. At **Savannah River**, a chemical salvage program has been initiated to dispose of or find uses for chemicals that are no longer needed. This initiative is being integrated into a more comprehensive sitewide program under a newly formed Chemical Commodities Group. At **Lawrence Livermore**, the Chemical Exchange Warehouse Program has been established to enhance the use and control of chemicals, as well as to reduce the quantity of hazardous waste at the site.

Chemical Storage Practices

Description of Vulnerability. Some of the most serious vulnerabilities identified at DOE facilities derive from the improper storage of hazardous chemicals. Proper chemical storage conditions include (but are not limited to) the adequacy and integrity of chemical containment (e.g., tanks, drums, secondary containment), segregation of incompatible chemicals, ventilation, temperature and humidity controls, fire protection, and protection from weather. Field observations indicate that these conditions are not always met at sites. Problems related to chemical storage at some sites have been exacerbated by a reluctance to disposition inventories of hazardous chemicals that no longer have defined uses. (See Planning for the Disposition of Chemicals, p. 27.) Too often, older facilities that are not designed or equipped for chemical storage are being used for this purpose.

Chemicals are stored in varying quantities at all DOE sites. Although many storage conditions and practices observed during this review were adequate, examples of improper chemical storage, some of which are serious, were noted at virtually all participating sites. The widespread occurrence of improper chemical storage across many DOE sites and the lack of consistent storage practices within individual sites indicate that increased attention to these issues is needed by local DOE and contractor organizations.

Examples. At the **Oak Ridge K-25 Site**, lithium hydroxide drums are stored in several vaults of the K-25 Process Building, an aging facility that does not have adequate temperature or humidity controls. (See Vulnerability CSV-OR-ORR-02 in Appendix E.) The drums, many of which

Some of the most serious vulnerabilities derive from the improper storage of hazardous chemicals.



Several vaults in the K-25 Process Building at Oak Ridge house corroding drums containing lithium hydroxide.

show significant corrosion, are stored on damaged wooden pallets that could fail and cause drums to fall and rupture. Although mitigating actions are being undertaken, personnel exposure to lithium hydroxide could result in caustic burns. As previously noted, about 4,500 cylinders containing as much as 50,000 tons of uranium hexafluoride are stored outdoors in another location at the K-25 Site. (See Planning for the Disposition of Chemicals, p, 28.) Because the cylinders are exposed to the elements, corrosive failure of some cylinders has produced uranium hexafluoride leaks, which, in the absence of secondary containment, could pose a chemical hazard to anyone in the immediate vicinity.

Brookhaven stores hazardous materials in older facilities that often do not provide the minimal safety systems common to general industry. (See Vulnerability CSV-000-01 in Appendix J.) The Hazardous Waste Management Facility lacks appropriate engineering controls and equipment to characterize and repackage hazardous materials. Therefore, resampling and repackaging, which are required because waste acceptance criteria and RCRA regulations have become more stringent, can only be performed by workers

wearing personal protective equipment. In general, predictive, preventive, and corrective maintenance of older facilities at Brookhaven has been deficient; for example, brass fittings on the chlorine gas manifold at Building 624 were corroded, and indications of a chlorine leak were observed immediately downstream from the pressure regulator on the six-bottle manifold. The inadequacies of facilities used to store hazardous materials at Brookhaven enhance the probability that storage containment will be breached, thereby exposing personnel to dangerous chemicals.

Hazardous chemicals and wastes are a legacy of decades of operations at **Los Alamos**. (See Vulnerability CSV-LANL-CH-01 in Appendix K.) Many of

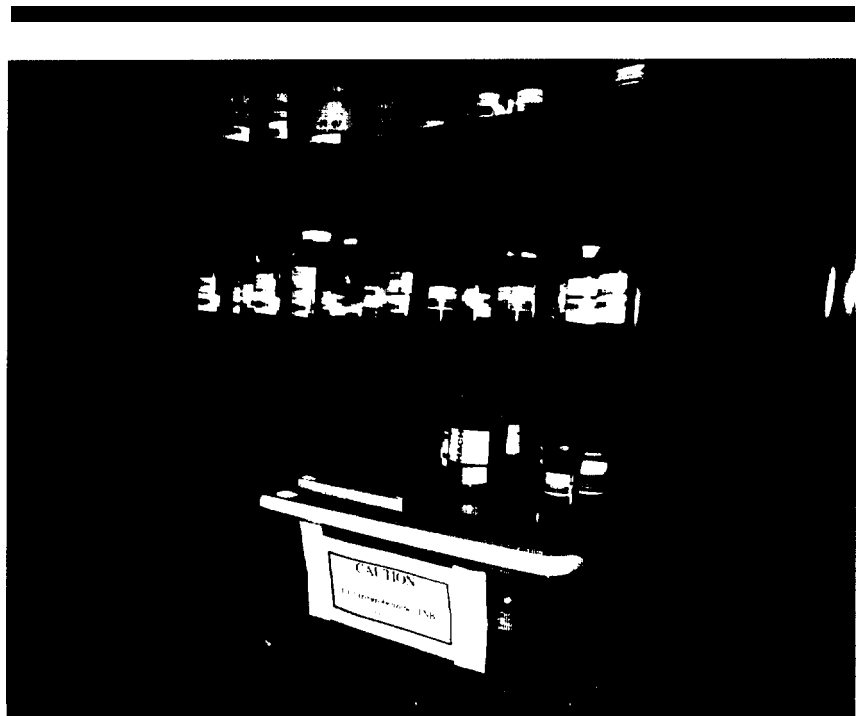


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these materials are being collected, characterized, stored, and prepared for disposal. Some are stored (at least temporarily) under less-than-satisfactory conditions that could lead to personnel hazards or environmental releases caused by leakage from corroded tanks, drums, or gas cylinders. About 500 waste cylinders are stored in TA-54, Area L. Many of these cylinders are old and corroded, and some (about 30) contain uncharacterized gases, including flammables (e. g., propylene, isobutane, hydrogen, and methane), corrosive gases (e.g., hydrogen fluoride, hydrogen chloride, nitric oxide, and sulfur dioxide), and toxic gases (e. g., arsine, phosphine, cyanogen, and phosgene). Efforts under way to resolve this vulnerability include completing the characterization of the contents of all waste cylinders and disposing of the cylinders as soon as possible. However, disposal of some cylinders will probably require the construction of new treatment units that could take years to complete. Leakage from corroded cylinders could release hazardous materials to the environment or expose workers to hazardous gases.

In Building 881 at Rocky Flats, potentially shock-sensitive chemicals were stored in metal office cabinets that were designed for interim storage of reactive chemicals. (See Vulnerability CSV-RFP-000-01 in Appendix I.) The location of these cabinets in the hallway near Room 127 was easily accessible to personnel moving through the first-floor corridors and could have resulted in the contents of the cabinets being disturbed. Also, the plutonium aqueous recovery system in Building 371 (shut down in 1984) has large quantities of plutonium nitrate left in the facility's tanks and ancillary piping. (See Vulnerability CSV-RFP-000-03 in Appendix I.) Some of the piping has no secondary containment, and none of the piping is constructed of material that is chemically suitable for long-term storage of corrosives such as nitric acid. A considerable fraction of the piping is located above floor level and in spaces that are difficult to access for inspection purposes. In the event of a leak, these circumstances



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would provide the potential for serious injury to workers conducting routine inspections of the piping.

At **Hanford**, large quantities of surplus hazardous materials have been stored for prolonged periods in production facilities being transitioned to deactivated status. (See Vulnerability CSV-RL-HAN-01 in Appendix G.) Without adequate engineered and administrative controls, prolonged storage of hazardous chemicals in shutdown or deactivated facilities could lead to personnel hazards or environmental releases caused by spills, evaporation, leakage from corroded tanks or drums, or decomposition of chemicals. The relatively long-term storage of hazardous chemicals under less-than-optimum conditions at the Plutonium Finishing Plant and the PUREX Plant represents a chemical safety vulnerability. Storage of corrosive chemicals (i.e., nitric acid, aluminum nitrate) in old tanks (for which corrosion surveillance may be difficult or impossible) poses the risk of leaks that could lead to environmental contamination and worker exposure. The carbon tetrachloride stored outdoors in drums near the Plutonium Finishing Plant was purchased for use in the plant process; however, if plans to deactivate the facility are implemented, the substance will no longer be needed. Meanwhile, carbon tetrachloride, a suspected human carcinogen, is being stored on poly-spill pallets with only a tent to provide protection from the weather. (See Planning for the Disposition of Chemicals, p. 29.) Several drums have already leaked because of corrosion. Although these releases have not resulted in injuries, the potential risk to workers is significant.

Storage of incompatible chemicals was cited at several facilities visited by the field verification teams. Because of space limitations at the **Oak Ridge National Laboratory**, a number of excess chemicals were placed together in a container at an open RCRA satellite storage area without regard to their potential incompatibilities. These chemicals included flammables, potential corrosives, and other materials. At **Savannah River**, storage of incompatible chemicals was observed in at least three areas. For example, gallon containers of nitric acid and hydrogen chloride acid were stored together in a corrosive storage cabinet at the 773-A Chemical Storage Facility. At **Rocky Flats**, materials identified as "reactive" were observed in the flammable storage area of the General Warehouse (Building 551). These chemicals were stored on a shelf with other types of chemicals and were segregated from one another by two strips of yellow tape. These examples all involve relatively small laboratory quantities that could nonetheless lead to fire, explosion, or worker injuries.

Commendable Practices. At the Idaho National Engineering *Laboratory*, Argonne–West has taken a proactive approach to the implementation of a model chemical hygiene program to improve storage, labeling, and administrative controls for all chemicals in the Analytical Laboratory. Specifically, Argonne–West has formulated a methodology for segregating normal laboratory chemicals, carcinogens, organics, and other materials and has reduced the inventory of high-risk chemicals such as ethers.

Condition of Facilities and Safety Systems

Description of Vulnerability. Many DOE facilities that contain or handle hazardous chemicals have deteriorated to the extent that they represent chemical safety vulnerabilities to workers and the environment. Deficiencies related to deteriorating roof structures and ventilation systems at many facilities either provide pathways for dispersing hazardous chemicals to the environment or reduce the level of protection afforded workers against chemical hazards in the workplace. Safety and essential support systems provide engineered barriers within operating facilities and are used, along with administrative controls, to protect workers, the public, and the environment from operational hazards—including chemical hazards. In many instances, these systems have not been effectively developed and maintained, thereby decreasing the margin of protection.

The deterioration of facilities and their associated safety systems is widespread at most DOE sites.

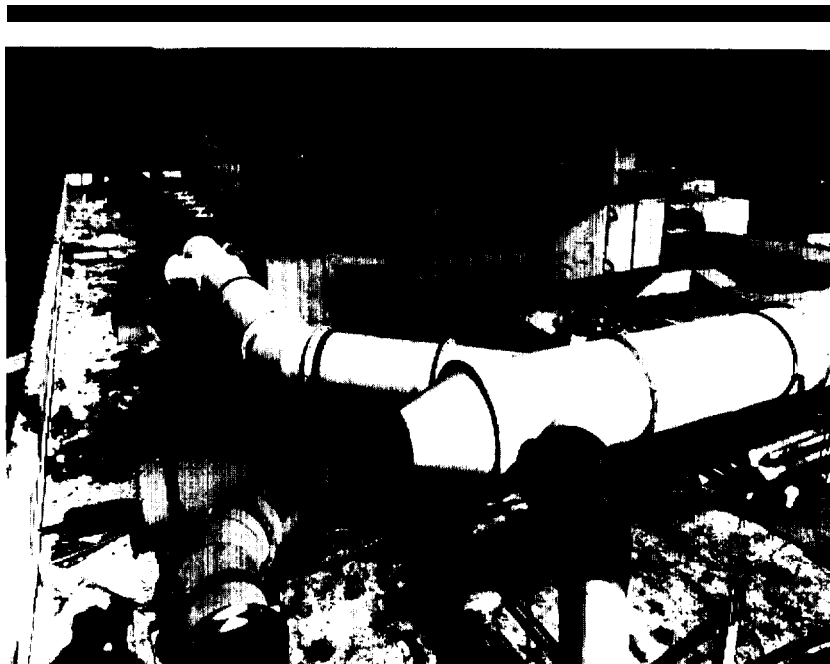
These deficiencies are due to:

- * **declining maintenance budgets;**
- **DOE's change in mission, which has resulted in an increase in the number of surplus facilities (i.e., facilities declared by DOE program offices to be available for other uses);**
- **lack of clearly understood and accepted ownership responsibilities for surplus facilities that have not been formally accepted by the DOE Office of Environmental Management for transition to D&D; and**
- **the overall aging of DOE facilities and equipment. (See Transition of Facilities From Active Status to New Missions or to Decontamination and Decommissioning, p. 56.)**

The deterioration of facilities and their associated safety systems is widespread at most DOE sites. The examples that follow provide evidence that facility structures are degrading (which causes a corresponding rise in the risk of worker exposures and environmental

releases); that maintenance of important safety systems has been inadequate; and that some facilities and safety systems are in use beyond their projected design life. DOE has not effectively addressed these issues. Since there is little evidence that this trend has been reversed, such conditions can be expected to worsen over time.

Examples. The Chemistry Laboratory (Building B-222) at Lawrence **Livermore** contains a large number of hazardous chemicals, including nitric acid, hydrochloric acid, and various thorium and uranium compounds. (See Vulnerability CSV-LLNL-FM-O1 in Appendix D.)



The degree to which hazardous chemical residues exist throughout the facility has not been established. The roof of this facility has deteriorated badly and leaks profusely, necessitating frequent repairs by maintenance personnel. During these repairs, the ventilation systems serving chemical laboratories and chemical fume hoods are shut down. Strict implementation of complex administrative controls must be enforced to prevent potential worker exposure to hazardous chemicals. The facility is still in use as a chemical laboratory, but once turned over for D&D, uncharacterized chemical residues throughout the building will be susceptible to dispersion and migration.

The roof of the Explosives Development Processing Facility at Los **Alamos** also shows evidence of cracks and leaks: (See Vulnerability CSV-LAN L-FM-02 in Appendix K.) As a result, chemical residues (uncharacterized high-explosive materials such as RDX) from processing explosive materials could be spread by drains that flow through old collection basins before entering an outfall. This situation may be exacerbated in the near future when processing activities are transferred to the facility from another DOE site because of the DOE weapons reconfiguration initiative.

At **Sandia**, an analytical chemistry laboratory complex is housed in aging facilities (Buildings 805, 806, and 807) that are being serviced by support equipment near the end of its expected life cycle. (See Vulnerability CSV-SNL/NM-FM-03 in Appendix L.)

Inadequate configuration management of these facilities has resulted in the gradual degradation of essential utilities and ventilation systems. These systems protect workers from toxic materials, carcinogens, and low levels of radionuclides handled in the laboratory complex. The affected systems include (1) the makeup air unit that provides heating and cooling for Building 805 (the unit must operate at full load because of the large amount of air exhausted through chemical fume hoods and localized chemical equipment ventilation systems); (2) water chillers in Buildings 805, 806, and 807; (3) chilled-water circulation pumps in Buildings 805, 806, and 807; and (4) several fume hood exhaust systems serving two or more laboratory rooms. Operations and maintenance personnel for these facilities reported that the systems in question were operating at, or slightly beyond, maximum design capacities; experiencing a higher than normal breakdown incidence rate; and contributing to suspect indoor air quality.

At Rocky *Flats*, more than 2,400 preventive maintenance items are delinquent by more than a month. (See Vulnerability CSV-RFP-000-04 in Appendix I.) Many of these items involve important safety systems that include exhaust fans; pressure relief devices; filter systems; chemical containment systems; and



More than 2,400 preventive maintenance items are delinquent at Rocky Flats.

various analyzers, detectors, and alarms. Many of these systems are intended to protect workers and the environment from chemical hazards. When such systems are not properly maintained, the likelihood of exposure to chemical hazards increases. Maintenance of important safety system equipment has been an issue at Rocky Flats for many years. When the field verification team visited Building 371, electric motors serving two of the three major ventilation fans were out-of-service, leaving only one ventilation fan to serve the building. This condition could lead to reduced airflow and, thus, reduce the level of protection to workers from such hazardous chemicals as nitric acid and plutonium nitrate. Further, the capacity of the feedwater pump for the cooling tower that serves the central storage vault in Building 371 had dropped from a 10,000-gallon-per-minute flow rate to 5,000 gallons per minute, which caused the temperature in the vault to rise from an optimum of 70–80 °F to 100 °F. The chemical storage vault houses reactive chemicals, including special nuclear materials, in an inert atmosphere. Temperature excursions of this type increase the potential for the release of hazardous materials to the surrounding environment.

At **Brookhaven**, the chlorine leak detector for the chlorine delivery system in the Central Water Treatment Plant was improperly placed, (See Vulnerability CSVN-BNL-000-03 in Appendix J.) Since the device would not immediately detect the flow of leaking chlorine, there is an increased likelihood that workers entering the chlorination room could be exposed. Some minimal safety systems are absent in the Hazardous Waste Management Facility at Brookhaven. (See Vulnerability CSVN-BNL-000-01 in Appendix J.) For example, safety showers at the facility were not maintained to an acceptable level. Functional maintenance testing for another emergency shower has not been conducted since 1991 due to water supply problems. Such testing is necessary to ensure that fully functioning showers will be available in the event of a hazardous materials spill.

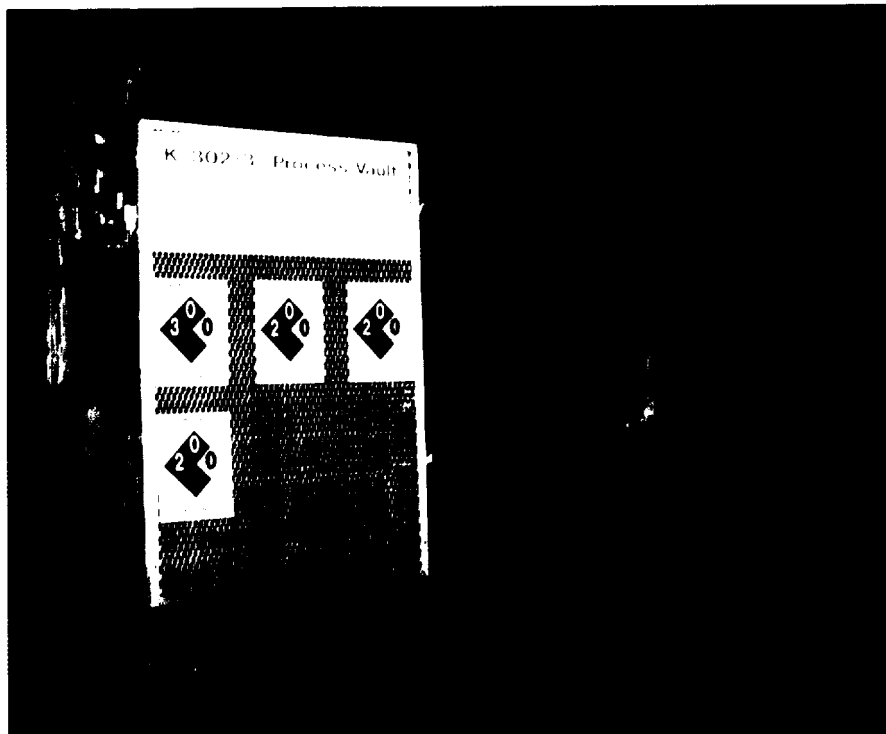
A restricted-workday case was recently recorded at **Savannah River** when a worker received second-degree burns after coming into contact with a 94-percent sulfuric acid solution sprayed from a broken 1-inch acid line. (See Vulnerability CSVN-SRS-000-01 in Appendix F.) The spray from the acid line reached an employee walkway at a distance of 20–30 feet away from the break. No safety system containment features or barriers were in place to protect employees in the nearby walkway, and no surveillance requirements had been established to monitor for deterioration of the acid line. Had the acid spray reached the worker's eyes, blindness could have resulted.

At the Oak Ridge K **K-25** Site, lithium hydroxide from the Y-12 Plant is being stored in Building K-25 (in Vaults 7, 7A, and 7B). (See Vulnerability CSV-OR-ORR-04 in Appendix E.) Although repairs are under way, the fire protection system in this area has deteriorated and the roof is leaking. Such deficiencies have reduced the reliability and effectiveness of vital safety systems, thereby increasing the potential for fire and airborne dispersal of lithium hydroxide.

Commendable practices. The removal of hazards (including chemical hazards) from facilities and more effective approaches to maintaining facilities have been implemented at some sites. At **Sandia**, a Facilities Space Management Program has been implemented to ensure that chemical safety hazards are addressed in surplus facilities before they are transferred to another user. This concept is effective for deteriorated facilities that clearly pose hazards to workers or the environment. At **Brookhaven**, the Maintenance Control Reporting System is being used to develop comprehensive work packages for corrective and preventive maintenance activities. This commendable practice provides a more effective mechanism for maintaining deteriorating facilities.

Abandoned and Residual Chemicals

Description of Vulnerability. Chemicals and chemical residues have often been abandoned in equipment or facilities that are no longer needed. This conclusion is based on observations at several DOE sites, indicating that sitewide requirements do not exist, or are not enforced, for characterizing and removing chemicals and chemical residues from surplus equipment or facilities. Few plans have been developed to dispose of such substances from aging or surplus facilities. These circumstances have contributed to potential vulnerabilities affecting workers, the public, and the environment through (1) workers inadvertently coming into contact with hazardous chemicals or chemical residues, particularly during D&D operations; (2) increased public access to areas and facilities containing



Deteriorating fire protection systems in the vaults used to store chemicals at the Oak Ridge K-25 Building increase the potential for fire and airborne dispersal of hazardous chemicals.

Chemicals and chemical residues have often been abandoned in equipment or facilities.

chemical hazards; and (3) environmental release of hazardous chemicals or chemical residues due to degradation of abandoned facilities or equipment.

Although the abandonment of chemicals and chemical residues in facilities and equipment does not appear to be widespread at all DOE sites, the examples found during field verification visits indicate serious vulnerabilities in this area that could result in worker exposures and environmental releases. The examples that follow describe those vulnerabilities and, in one case, discuss their actual

consequences for worker safety. In many instances, contractor management has not established sitewide requirements for characterizing and removing chemicals and chemical residues from abandoned facilities and equipment. This situation does not appear to be improving. Until DOE fully implements a consistent set of requirements for characterizing and removing chemicals and residues from abandoned facilities and equipment, these vulnerabilities will persist.

Examples. Some facilities at **Savannah River** have been abandoned with chemical residues left in place. (See Vulnerability CSVN-SRS-000-02 in Appendix F.) The 412-D Heavy Water Extraction Facility, for example, was abandoned with uncharacterized chemical residues left inside piping and tanks.

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The tank residue was an oily substance with a pH of about 3.3; the pipe residue was a yellow, unanalyzed solid; and both may have contained sulfur. While D&D operations were being carried out at this facility, a worker apparently inhaled noxious gases after a pipe containing uncharacterized chemical residues had been cut with a torch. In another case at the abandoned 184-P Power House, the field verification team observed uncharacterized chemical residues near the cleanout door at the base of the smokestack, a location that was readily accessible by workers. (See Characterization of Chemicals, p. 19.)

At **Rocky Flats**, the plutonium aqueous recovery system located in Building 371 was shut down in 1984. (See Vulnerability CSV-RFP-000-03 in Appendix I.) Large quantities of plutonium nitrate were left behind in the facility's tanks and ancillary piping. Some of the piping has no secondary containment, and the piping is not constructed of material that is chemically suitable for the long-term storage of corrosives such as nitric acid. In the event of a leak, these circumstances create a potential for serious injury to workers conducting routine inspections of the piping.

Several Oak Ridge facilities have been placed in caretaker status without proper cleanup of chemicals or chemical residues. (See Vulnerability CSV-OR-ORR-03 in Appendix E.) For example, Building K-725 at the K-25 Site was used from 1946 to 1952 to support the Nuclear Energy for Propulsion of Aircraft Project and was abandoned without cleanup. The building and ductwork are known to be contaminated with hazardous materials, possibly including beryllium, mercury, and uranium. The shielded-cell facility in Building 3047 at the **Oak Ridge National Laboratory** houses a sump known to contain uncharacterized radioactive chemical residues left behind when chemical processing was discontinued. In Building K-25, chemical residues such as Freon, lubricating oils, and uranium hexafluoride were left in place, along with substantial amounts of uranium. In the event of their release, these abandoned chemicals and chemical residues could present hazards to workers and the environment.

At **Lawrence Livermore**, only limited strategic planning has been conducted for the disposition of aging or inactive facilities that may contain hazardous or mixed waste. (See Vulnerability CSV-LLNL-FM-01 in Appendix D.) The Chemistry Laboratory (Building 222) is about 40 years old and contains a variety of hazardous and toxic chemicals, including nitric acid, sulfuric acid, various uranium and thorium compounds, and mixed waste residues. Characterization of chemical residues has not been completed for the facility, and plans have not been finalized for their removal before D&D begins. Because many of these residues may be susceptible to migration or dispersion, they represent a potential vulnerability to workers, the public, and the environment.

Commendable Practices. During field verification visits, commendable practices involving the removal of chemical residues in process equipment were observed at some sites. At the **Idaho National Engineering Laboratory**, chemical storage and processing systems in the Fluorinel Dissolution Process and Fuel Storage Facility

were properly flushed and cleaned of chemical residues. The processes used for these operations were documented. A similar process was used at **Sandia** for the Light Initiated High Explosive Facility, which was thoroughly cleaned of chemical residues before it was placed in safe standby.

Inventory Control and Tracking

Accurate inventory information is a crucial aspect of chemical safety.

Description of Vulnerability. Most DOE sites have established systems to record and monitor chemical inventories. However, such systems do not always provide up-to-date information about the quantity and location of these chemicals, nor do they provide **information on all chemicals in use at a particular site.**

DOE guidance on what constitutes an acceptable chemical inventory system is limited. Systems currently in place have been developed and implemented to meet criteria established by the implementing site. As a result, there is considerable disparity in the quality and effectiveness of these systems at different sites. Accurate inventory information is a crucial aspect of chemical safety because it enables implementation of systems to control and minimize the onsite quantities of hazardous chemicals and it provides emergency responders (such as firefighters) with the information they need to respond to emergencies in areas where hazardous chemicals are stored. Hence, the absence of accurate information on chemical inventory increases the possibility that workers and the public will be exposed to hazardous chemicals or that chemicals will be released to the environment.

Management at virtually all DOE sites has recognized the need for chemical inventory control to protect workers, the public, and the environment from damaging incidents involving hazardous chemicals. The inventory control system at some facilities is used primarily to fulfill the reporting requirements of Title III (Emergency Planning and Community Right-to-Know) of the Superfund Amendments and Reauthorization Act. Other facilities also use their systems as real-time or near-real-time monitors of the onsite inventory of chemicals. More sophisticated systems under development (see Commendable Practices in this subsection) will be able to provide information on both the quantity and the location of hazardous chemicals. However, as illustrated by the examples below, the urgency for committing the effort necessary for achieving effective chemical inventory control in an acceptable period of time will require greater emphasis and attention by local DOE and contractor organizations.

Examples. The Chemical Control System at Rocky Flats was designed solely to track chemicals regulated under Title III of the Superfund Amendments and Reauthorization Act. (See Vulnerability CSV-RFP-000-O1 in Appendix I.) As a result, plant management cannot provide accurate and complete inventories of hazardous chemicals for all facilities on a real-time or near-real-time basis. The inability to provide accurate and complete inventory information on a real-time basis affects the safe management of hazardous chemicals by limiting custodial responsibility to the managers of those few buildings (e.g., Building 559) in which systems have been implemented to track all chemicals. It also limits the ability of site managers to control building

modifications and other changes that could support new missions or transition to D&D. Accurate information about current chemical inventories for each area is required for the effective management of these changes. The range of hazardous materials in various buildings at Rocky Flats includes organic solvents, organic and inorganic acids and bases, lead-based paint, carcinogens, heavy metals, and hazardous and mixed wastes. The absence of effective inventory controls creates the potential for exposure of workers and the

public to hazardous chemicals or for fires and explosions caused by the proximity of incompatible chemicals. Building 881 at Rocky Flats may be used as a pilot for a plant-wide project to address these weaknesses.

At **Savannah River**, a system has not been established to manage chemicals from their procurement through final disposition. (See Vulnerability CSV-SRS-000-03 in Appendix F.) Furthermore, there



Ineffective inventory and tracking systems could lead to co-locating incompatible chemicals, as shown here in a Building 551 storage room at Rocky Flats.

is no system for tracking hazardous chemicals after they are delivered to the site. Savannah River management has recognized this weakness and is establishing a Chemical Commodities Management Group, which will be functional by the end of 1994.

Management at **Sandia** has developed and is using a data base (i.e., ChemMaster) to maintain an official chemical inventory record. However, the system has serious deficiencies. First, it does not actually track hazardous chemicals; rather, it indicates the maximum quantities that could be in inventory. Second, the chemical inventories of some organizations are not updated promptly.

Although **Brookhaven** maintains chemical inventory systems, containers of a hazardous chemical (ethyl ether) that were found in a Brookhaven laboratory fume hood were not included on the chemical inventory lists. (See Vulnerability CSV-BNL-000-O1 in Appendix J.) Ethyl ether is a highly volatile, flammable liquid that, if undetected, could adversely affect worker performance or contribute to the potential for fires or explosions. Other hazardous chemicals at Brookhaven may have been omitted from formal site inventories because procedures for compiling such inventories are lacking. Clear definition is not provided for what materials should be tracked, and no mechanism has been established for identifying holdings of hazardous chemicals that may have existed before the current systems were implemented. Thus, the potential exists for accumulating hazardous chemicals in operations areas. In general, the lack of specificity in the information provided by chemical inventories contributes to the potential for exposing workers to hazardous chemicals. Both Sandia and Brookhaven plan to implement new systems that will correct these deficiencies; however, for the present, the chemical inventory control systems are flawed and weaknesses based on inaccurate or incomplete information persist.

Commendable Practices. Field verification teams observed commendable inventory control and tracking practices at a number of sites. Pacific Northwest Laboratory at **Hanford** has implemented the computer-based Chemical Management System, which serves as a model for other sites and is being adapted for use at **Brookhaven, Lawrence Berkeley National Laboratory, and Argonne National Laboratory- West**. The Facility Information Management System under development at **Lawrence Livermore** could ultimately have the potential to access chemical inventory information from any site location. **Los Alamos** and other sites have developed methods to use bar-coded labels on containers of

hazardous chemicals and waste to facilitate tracking. Several sites have reduced the use of chlorine gas and instituted more stringent administrative controls over its use. **Savannah River** has replaced chlorine gas with the much-less-hazardous sodium hypochlorite for use in its primary domestic water treatment plant.

